



Introduction

Environmental Management (EM) Engineering and Technology activities identify and advance technologies, processes, and technical practices that improve the performance of environmental management projects over their entire lifecycle, from planning to disposal. It provides the U.S. Department of Energy (DOE) with development and implementation of engineering concepts, practices, programs and advance technologies for improvement of design, construction, and system/facilities management activities.

Engineering and Technology investments will provide the engineering foundation, technical assistance, new approaches, and new technologies that contribute to significant reductions in risk (both technology and safety and health), cost, and schedule for completion of the DOE mission in cleaning up the legacy waste and environmental contamination brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research.

Engineering and Technology currently focuses on the following three areas: Groundwater and Soil Cleanup; Deactivation and Decommissioning; and Tank Waste and Waste Processing at the largest EM sites: Savannah River, South Carolina; Idaho; Hanford, Washington; Oak Ridge, Tennessee; and Portsmouth/Paducah, Ohio/Kentucky.

This document describes some of the developments funded by the Technology Development and Deployment program to significantly enhance EM's work at these sites.

Groundwater and Soil Cleanup

Monitored Natural and Enhanced Attenuation or Cleanup of Chlorinated Solvents

A national project led by the Savannah River National Laboratory (SRNL) studied nature's own ability to clean harmful chlorinated solvents from the groundwater, and how to apply information gained to expand those abilities. Results of this three-year project are expected to accelerate cleanup by a minimum of 10 years for DOE sites that have groundwater plumes contaminated with chlorinated solvents.

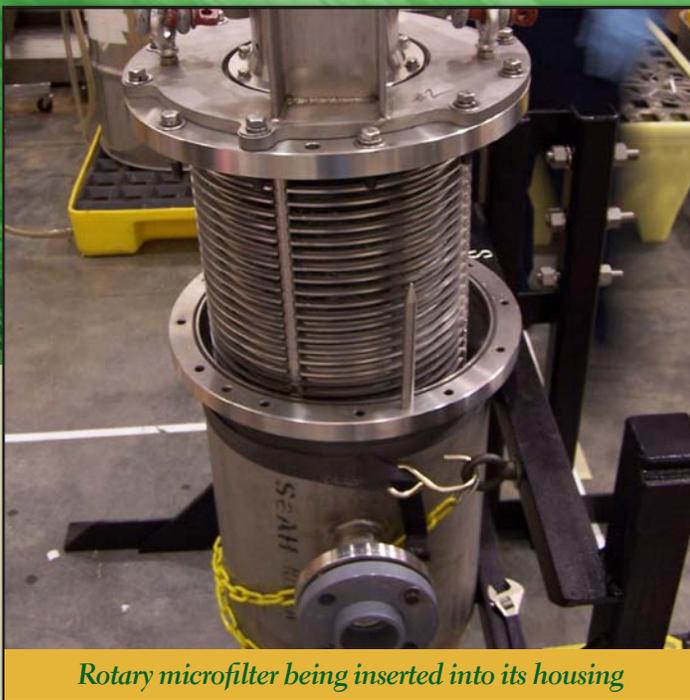
At the Savannah River Site (SRS), the project is expected to make it possible to accelerate chlorinated solvent cleanup by at least 20 years.

Monitored natural attenuation (MNA) involves allowing natural mechanisms, like naturally occurring microorganisms, to break down or isolate contaminants. Through 14 innovative research studies and other related activities, the project fostered the development of tools to measure the progress of MNA and to assist sites in making the decision whether or not to transition a contaminated site from active remediation to a natural process, and also explored three key concepts to support decision-making. The first involves employing a mass balance to evaluate whether a plume is stable or shrinking. The second concept, enhanced attenuation, enables a site owner to transition from an active cleanup technology to a designed technology that gives a "boost" to natural mechanisms, allowing them to become self-sustaining. The third is characterization and monitoring tools and strategies that are based on the concept of sustainability.

A key feature of the project was collaboration with the Interstate Technology and Regulatory Council (ITRC), a coalition of regulators from 46 states whose charter includes increasing the rate at which new environmental technologies are implemented. This collaboration led to the ITRC incorporating the most promising technologies and concepts from the project into a technical-regulatory guidance document and subsequent training programs, thus facilitating acceptance by regulators.

The Mission of Environmental Management Engineering and Technology is to identify and advance technologies, processes, and technical practices that improve the performance of EM projects over their entire life-cycle.





Rotary microfilter being inserted into its housing



Houdini remotely operated vehicle

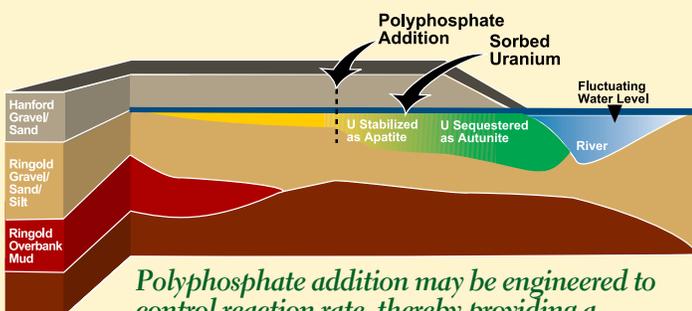
Deactivation and Decommissioning

Stabilizing Uranium Near Former Nuclear Fuel Facilities

Research by Pacific Northwest National Laboratory (PNNL) has shown that portions of the uranium plume left in the Hanford Site's soil by waste from previous nuclear production can be immobilized by injecting a soluble form of polyphosphate into porous subsurface areas where uranium resides. This injection forms an insoluble uranyl phosphate, autunite, which sequesters uranium in the oxidized form. Immobilizing the uranium keeps it from migrating through the vadose zone to the groundwater. A field test will take place summer 2007.

Capturing Chromium, A Former Rust Inhibitor Used in Nuclear Reactors

At a former reactor on the Hanford Site, PNNL is using microbes to create an environment that will treat chromium, nitrate, and other materials in the groundwater. By reducing these contaminants, they will be able to increase the longevity of the In Situ Redox Manipulation barrier, a permeable subsurface barrier capable of destroying or immobilizing targeted contaminants. Field-scale tests will be conducted at the reactor site.



Polyphosphate addition may be engineered to control reaction rate, thereby providing a horizontal region of sequestration.

Monitor Determines Radium Levels in Real Time

Idaho National Laboratory (INL) and Oak Ridge National Laboratory (ORNL) developed a gamma attenuation monitor for use at Fernald to determine in real time the amount of radium in the processed ore stored in the silos, which was being converted to a cement form for permanent disposal. Data from this instrument was fed in real time into the process for each batch, allowing the concrete recipe for each batch to be adjusted for the percent solids and radium level in the ore. Using this information allowed the number of cans of immobilized ore to be reduced to 7,500, down from the 15,000 originally projected. The estimated cost savings by having the site close four months early and produce 7,500 fewer cans was estimated by the site contractor to be \$75M. The new technology to allow real-time monitoring of radionuclide levels is being actively commercialized.

Technical Assistance for Alternative Environmental Survey Technologies

INL has developed and deployed a suite of systems that rapidly scan, characterize, and analyze surface soil contamination. Used at DOE laboratories and cleanup sites, these systems have assisted those sites in achieving significantly better cleanup results by reducing the cost, worker exposure and schedule compared to baseline remediation characterization constraints faced by these sites before implementation of part or all of the capabilities of these systems.

At the Fernald Closure Project (completed October 2006), a total estimated \$34M cost savings was achieved using INL real-time characterization systems to reduce the cost and schedule impacts associated with physical sampling and laboratory analysis to establish a fast track to closure. Environmental Protection Agency and stakeholders approved of this approach.





Filling canisters with radioactive waste glass at the Defense Waste Processing Facility



Modified MST

Modified Sorbent Improves Removal of Plutonium and Other Actinides

SRNL and Sandia National Laboratories led a project to develop improved sorbent materials for removal of strontium and actinides from certain wastes at the Savannah River Site. This project identified a method to modify the synthesis of monosodium titanate (MST) that produced materials which exhibited significantly improved performance for strontium and actinide removal. The superior performance of the modified MST may allow waste treatment facilities to increase throughput as much as three-fold, while using one-fourth to one-half the quantity of sorbent.

MST is an inorganic sorbent material capable of removing strontium and actinide elements from salt solutions such as wastes stored at DOE's Hanford and Savannah River Sites.

The modified MST has been successfully scaled to production by a commercial vendor. Further development studies are planned to support deployment of this improved sorbent in the Salt Waste Processing Facility and Actinide Removal Project at the Savannah River Site, as well as other separation applications within the DOE, the Department of Defense, and private industry.

Technologies for Underground Tank Remediation

ORNL helped develop, then tested and deployed over 30 technologies during underground tank remediation activities. Innovative approaches and technology deployments reduced the baseline tank remediation schedule by over 10 years and resulted in cost savings of \$120M. These innovations included the Houdini remotely operated vehicle, which was instrumental in sludge removal. The vehicle's manipulator arm can hold various tools, and an attached plow is used to push sludge and debris into piles for removal. On-line cameras provide additional views of waste retrieval activities.

The Mound Closure Project Radioisotope Thermal Generator (RTG) cleanup project was the working demonstration site to demonstrate the Actinide X-Ray In Situ Scanning System (AXISS) that was developed to achieve quantification of plutonium-238 at 30 pCi/g. This system allowed project personnel to monitor the soil cleanup and to ensure that haul roads did not become contaminated and further risk the transport of contaminated soil off site.

At the Idaho Closure Project (ICP), use of the system has dramatically improved their project cost and schedule baselines by having available to them instantaneous quantitative in situ measurement data without having to collect physical samples. State regulators have approved this change to the ICP baseline approach.

Tank Waste and Waste Processing

Removing Troublesome Aluminum and Chromium from Waste Before Vitrification

By removing the insoluble aluminum and chromium from tank waste before vitrification, the Waste Treatment Plant at Hanford and the Defense Waste Processing Facility at Savannah River can dramatically reduce the number of high-level waste canisters produced and reduce the overall life-cycle costs. So, PNNL developed a caustic leaching process to remove aluminum. This process is now part of the baseline pretreatment flowsheet for the Hanford Waste Vitrification Plant.

Also, PNNL developed the oxidative leaching baseline for chromium by conducting tests with multiple oxidants and varying conditions to optimize the process for leaching chromium out of the tank waste prior to vitrification. In addition to its use at Hanford's Waste Treatment Plant, this technology is being considered for deployment at the Savannah River Site.



Increasing Sulfur Loading Significantly Reduces Hanford Glass Volume

A new high sulfur glass formulation for low-activity radioactive waste, developed by PNNL with support from Idaho National Laboratory, SRNL and Khlopin Radium Institute, will reduce the volume of low-activity waste glass at Hanford by roughly 45%. The current glass formula can only accommodate a low concentration of sulfur; this current baseline sulfur loading, dubbed "Rule-of-Five," would result in more than 656,000 metric tons of low-activity waste glass. The new formula will significantly increase the target sulfur loading, decreasing the total volume of glass needed to dispose of the waste.

Characterization Technologies Enable Shipment of Large Transuranic Containers

New technologies developed for the nondestructive assay (NDA) and nondestructive examination (NDE) of oversized boxes containing materials contaminated with transuranic (TRU) materials will allow large TRU containers to be efficiently shipped to the Waste Isolation Pilot Plant (WIPP) without repackaging or resizing. Waste being shipped to WIPP must be characterized before shipment to ensure that it meets the facility's requirements, but many DOE sites have oversized containers of TRU waste, which cannot be directly characterized by existing NDA and NDE methods. By enabling the characterization of the contents of these oversized containers without the need for repackaging, the new NDA and NDE technologies will cut shipping costs by \$600-900M, and save 8-12 years in schedule, while greatly reducing hazards to workers. First deployment of these new technologies will be at the Savannah River Site, where they will become operational in FY08.

Reformulating Savannah River Glass Increases Vitrification Rates

Enhancements at the Savannah River Site's Defense Waste Processing Facility (DWPF) could allow the facility to complete its mission of vitrifying all of the high-level waste stored in SRS' tanks five years early, saving an estimated \$330M per year in DWPF and tank farm operating costs, or a possible total savings of \$1.7 billion.

Among the enhancements are physical and chemical changes to the glass formula, which significantly increase waste throughput, reducing production time and mission cost. These changes increased the waste throughput rate from ~40 to ~55 lb/hour treating more waste per year. They also increased waste loading from 28% to 38%, putting more waste in fewer canisters, which reduces canister storage and disposition costs.

Small Column Ion Exchange to Remove Cesium

ORNL and SRNL developed the Small Column Ion Exchange, a process for decontaminating high-level waste at Savannah River Site. The process uses an ion exchange material, crystalline silicotitanate, to remove cesium-137 from the waste, allowing it to qualify for final disposal in the Savannah River Site's Saltstone Facility. The process is to be performed inside a waste storage tank, eliminating the need for construction of another facility.

Modifications to Commercial Filter Aid in Preparing Low-Activity Waste

As part of the Small Column Ion Exchange, SRNL has developed modifications to a commercially available rotary microfilter for use to pre-filter the waste, removing solid particles that would plug the Small Column's ion exchange column. When tested, the resulting filter showed six times the filtration rate as was achieved with traditional cross-flow filters. SRNL has submitted a patent application on the modifications that made the filter suitable for radioactive use. Two full-scale units that use the improvements were procured; one has been tested on ion exchange prefiltration and the other on sludge washing applications.

Deployment of Gubka at Fernald to Disposition Wastes

The INL conducted a joint research project with Russian institutes at St. Petersburg, Krasnoyarsk, and Zheleznogorsk on the development and application of a porous crystalline matrix for stabilizing liquid wastes. These efforts resulted in final disposition of a very challenging mixed waste stream stored at the Fernald site, approximately 25 L of radiological laboratory standard solutions that required stabilization and disposal before the laboratory facilities could be decommissioned.

The process is based on the use of a silicate fly ash from specific Russian coal-fired power plants, and is referred to as Gubka, which is the Russian word for "sponge."

The dried Gubka blocks were disposed under the Nevada Test Site shallow land burial disposal criteria used for other similar low-level wastes.

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